

Design and Implementation of A VHF Tri-Loop Antenna for 2-Meter Amateur Band

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ABSTRACT

This paper presents the design and implementation of a triangular loop antenna using aluminum tubing of diameter 10mm with high electrical conductivity and reflecting ability. The antenna operates in very high frequency (VHF) band covering a frequency range of 140 to 150MHz. It has a gain of 3 dB and a radius of coverage of about 100 kilometers. It was constructed as a prototype antenna and tested at the author home base (QTH) with grid locator of PK23CO, where signals from DW4PGS, DW4PLN, DW4GSV, and DV4RBC were received with sharp audible sound(Q5) and full signal strength(S9). Better receptions were recorded for PD03, KB912-19, and KB951 – B157 on days with good propagation. Measurement result shows that the proposed antenna can work properly and meet well to be used in as reliable low cost homebrew effective VHF wide band antenna and it is an omnidirectional antenna.

KEYWORDS: VHF Communication, Radio Waves, Triangular Loop

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INTRODUCTION

Communication is connecting people. It enables humans to share ideas and experiences indirectly or vicariously fostering interpersonal bond. Communication is the main reason why the earth keeps on moving forward.

Radio communication sends signals by radio to communicate with other. From Audio, Telephony, Television, Satellite, Navigation, and the advance used of Radio communication signals in Radar Technology, Data (Digital Radio), Amateur Radio. In today's world, radio communication is widely used. Without radio communication we maybe still are living in last century.

Radio systems used for communications have the following elements. With more than century of development, from the time of Marconi to present. The communication system process is implemented by a wide range of methods and been specialized for different communications system.

Each system contains a transmitter. A transmitter consists of a source of electrical energy, producing an alternating current (AC) of a desired frequency of oscillation. The transmitter contains a system to modulate (change) some property of the energy produced to impress a signal on it. The transmitter sends the modulated electrical energy to a tuned resonant antenna. The resonant antenna structure for transmit converts the rapidly changing alternating current into an electromagnetic wave that can move through free space.

The electromagnetic wave is intercepted by a tuned receiving antenna. The resonant antenna structure for receiving captures some of the energy of the wave and returns it to the form of oscillating electrical currents. At the receiver, these currents are demodulated, which is converted to a usable signal form.

Frequency modulation varies the frequency of the carrier. The instantaneous frequency of the carrier is directly proportional to the instantaneous value of the input signal. Digital data can be sent by shifting the carrier's frequency among a set of discrete values, a technique known as frequency-shift keying. Frequency Modulation (FM) is commonly used at VHF radio frequencies for high-fidelity broadcasts of music and speech. Normal (analog) TV sound is also broadcast using FM.

Antenna

An antenna is an electrical device which converts electric currents into radio waves, and vice versa. It is usually used with a radio transmitter or radio receiver. In transmission, a radio transmitter applies an oscillating radio frequency electric current to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves (radio waves). In reception, an antenna intercepts some of the power of an electromagnetic wave in order to produce a tiny voltage at its terminals, that is applied to a receiver to be amplified. An antenna can be used for both transmitting and receiving (ARRL, 1999)

The Loop Antenna

A loop antenna is an antenna consisting of loop of electrical conductor such as wires, tubing, or solid metals. Its end is connected to a balanced transmission line. For this design, the used of resonant loop antenna is utilize where the length of the loop is approximately equal to the wavelength. Self-resonant is typically used for VHF and UHF. Compared to the dipole or folded dipole, it transmit less towards the sky or ground, giving it somewhat higher in gain in the horizontal direction. The use of a triangular loop rather than the conventional circular or quad is utilized since there is no recorded article or known experiment regarding the exploration of a triangular loop antenna for VHF band. Most loop antenna is in a form of a Delta Loop is design for HF band. Also this study will further evolve in the design of a collinear triangular loop.

The triangular loop is shape as triangle with its apex at the top and two edge corners at the bottom where the feed line is attaché d to one of its corner.

Design Consideration

To design this tri-loop antenna, using aluminum tubing of diameter 10mm was chosen and used to make the elements. This choice was made for that it is the most common type of antenna element in the area and high electrical conductivity and also resistance to corrosion.

The length of the tri-loop was determined based on a frequency of 145.00mhz (center frequency for amateur band in the Philippines).

Using the modified formula of finding the length of the loop develop by L.B. Cebik,

$$L = 1065/f(\text{mhz}) \text{ for VHF frequency}$$

Where:

L= length of the loop

1065 = is a constant used in the design of most commonly

loops such as circular and quad

F = frequency in megahertz.

From the given formula the result dimension of the loop is $L=1065/145\text{mhz} = 7.35$ feet. Since this is a tri-loop, the dimension of each side is 2.24ft. The full dimension is shown in the figure below.

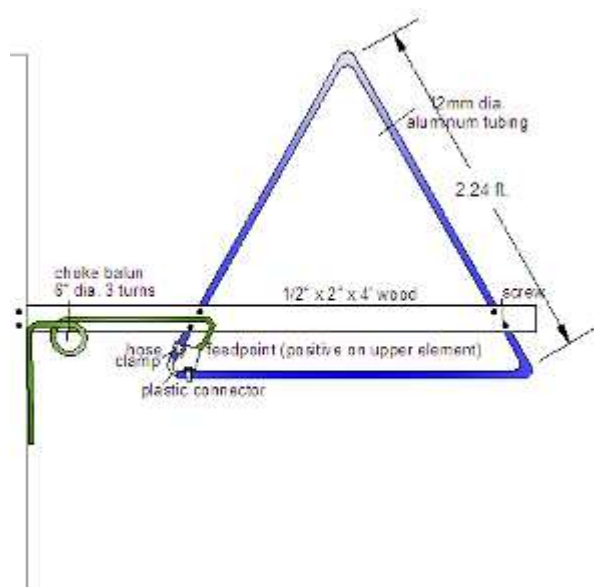


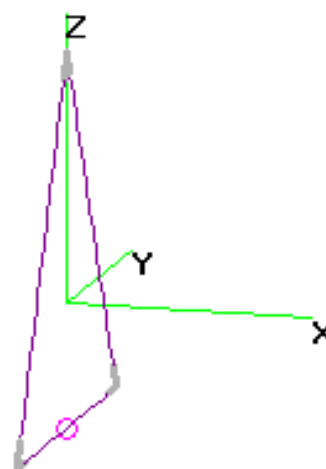
Figure1. Diagram of the Tri-loop antenna

The Materials used for building and implementation of the project.

Quantity	Materials
1pc - 8ft.	12 mm Aluminum Tubing
1pc - 1/2"x2"x4'	Good Lumber
1pc	Plastic connector bended 60 deg.
2 pcs - 10mm dia.	Hose clamp
4pcs - 1/4"	Metal screw
1 pc - 2-3" dia.	U-clamp
6 pcs	Plastic straps
1 sachet	Waterproofing sealant
1 roll	Coaxial Cable

Analysis of the Performance

Using 4NEC2 software to simulate the radiation pattern and other performance criteria of the antenna. The dimension use for this simulation is the dimension from the results using the formula of the general HF loop antenna. The result gives an outstanding 3 dB.



Filename	tri-loop.out	Frequency	145	Mhz
		Wavelength	2.068	mtr
Voltage	103 + j0 V	Current	0.63 + j0.45 A	
Impedance	108 - j77	Series comp.	0.085	uH
Parallel form	163 // -j228	Parallel comp.	0.25	uH
S.W.R. 50	3.43	Input power	65	W
Efficiency	100 %	Structure loss	0	W
Radiat-eff.	100 %	Network loss	0	W
RDF [dB]	2.95	Radiat-power	65	W
Environment	FREE SPACE			
Comment	trilogi 2meter (1.6mm wire, 1 lamda boom) *.Out loading-time=0.055			
Seg's/patches	45	start	stop	count
Pattern lines	5329	Theta	-180	180
Freq/Eval steps	1	Phi	0	360
			73	5
			73	5

Figure2. The 4NEC2 software analysis of the antenna

Optimize performance of the antenna

To optimize the performance of the quad loop, I use 4NEC2 optimization program to get the maximum performance of the antenna by changing the dimension of the width of the system.

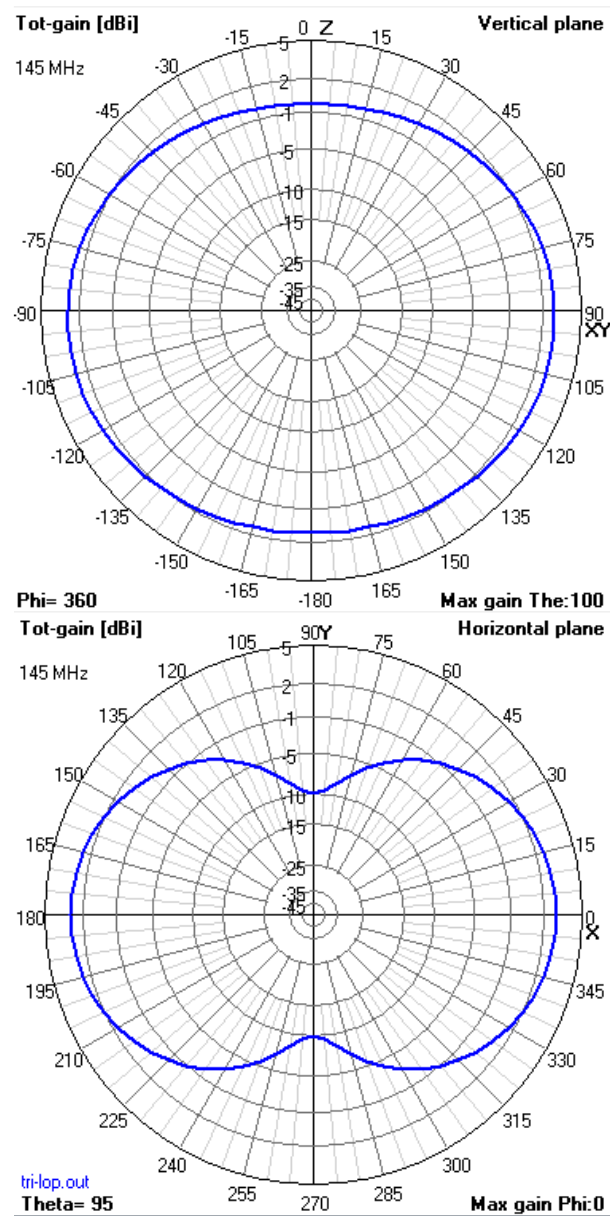


Figure3. The result gives us 3dB and Efficiency of 100%.

Implementation Procedure

The antenna was constructed using aluminum tubing with a 12mm diameter for the element, 1/2" x 2" x 4' wooden holder, 2" diameter GI pipe as boom, hacksaw for cutting the materials, gimlet for drilling holes, screw nails for fastening the elements to the boom, measuring tape, 50-ohm coaxial cable as transmission line and feeders to house the terminals.

The elements were first measured, bend using pipe bender and cut out of the aluminum rail and holes drilled at their holder location. The holder is then fitted with u-clamp for the attachment to the mast. The two endpoint of the elements is then attached and connected by a plastic connector (or a coaxial inner core)

The feeder lines were fixed to the element on one of the lower corner of the tri-loop with hose clamp. The hose clamp will enable the installer to adjust the SWR reading by simply moving in and out the clamp on the element from the corner endpoints. With the feeders in place, cover the connection of the feeder with water proofing sealant as not to introduce corrosion and rust in the connector. Finally, the coaxial cable from the feed point is connected to a VHF Transmitter Radio.

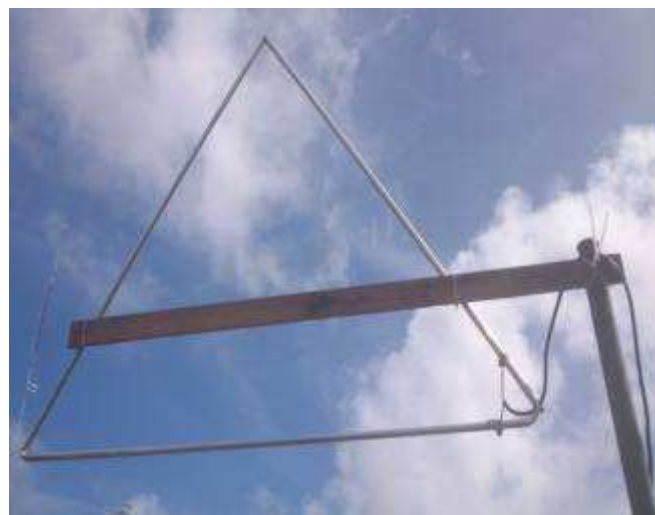


Figure4. Actual Completed Antenna

Testing Procedure and Results

1. Antenna Analyzer

The antenna is tested first by getting the SWR reading to get the optimized performance in terms of receive and transmit capability. The SWR reading of the antenna was then tested using MFJ Antenna Analyzer. The result gives a promising and positive data.



Figure5. Using the MFJ Antenna Analyzer to test the antenna for SWR and Impedance

2. Actual Transmission (TX/RX)

The second method is to test the antenna by transmitting. The antenna is then connected to a Transmitting radio set using Icom 2200H with an output power of 65Watts. The radio is connected to the antenna by coaxial cable with impedance of 50 Ohms. The testing covers all the VHF radio frequency band and focused on 136.000 – 160.00Mhz. The result is shown below with the actual testing of the antenna unit.



Figure6. Actual SWR reading with Diamond SX-200 Meter Using an Icom 2200H with 65 watts of output power in an amateur frequency.

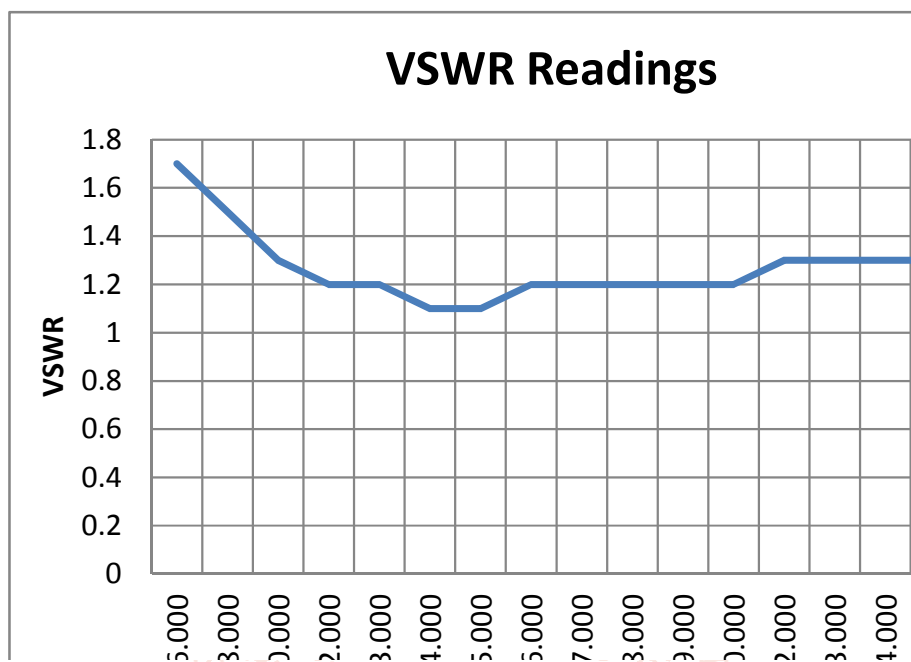


Figure7. The VSWR reading on corresponding VHF Frequency

3. Signal Check for Strength and Clarity of the transmission.

The audio quality and the signal strength were then tested with conversation with other radio operation from different location. The antenna is installed at DW4DXT QTH or home base with grid locator PK23CO. Below shows the table of the strength reading and quality of audio from different operator and different locations.

Table1. Signal strength and audio quality of transmission

Operator(s) Station	Grid Locator/ Location	Frequency (Mhz)	Distance (KM)	Audio Quality	Signal Strength
DW4PGS (Fixed Station)	Virac, Catanduanes	145.580	3	Q5	S9
DW4PLN (Fixed Station)	San Andres, Catanduanes	145.580	12	Q5	S9
DY4TMD (Mobile)	Bato, Catanduanes	146.880	10	Q5	S9
DW4GSV (Fixed Station)	Cagraray Island, Albay	145.580	45	Q5	S5
KB951 –B157 (Fixed Station)	Tabaco City	146.020	58	Q5	S3
DY4MDJ (Fixed Station)	Malilipot, Albay	145.460	58	Q5	S5
DV4RBC (Fixed Station)	Sto Domingo, Albay	144.160	60	Q5	S9
Hotel Kilo (Fixed Station)	Naga City	145.580	105	Q1	Busy/DS
PD03 (Fixed Station)	Goa, Camarines Sur	146.870	80	Q3	Busy
MAM (Fixed Station)	Tigaon, Camarines Sur	145.580	78	Q5	S1
KB912-19 (Fixed Station)	Magallanes, Sorsogon	146.170	93	Q2	Busy

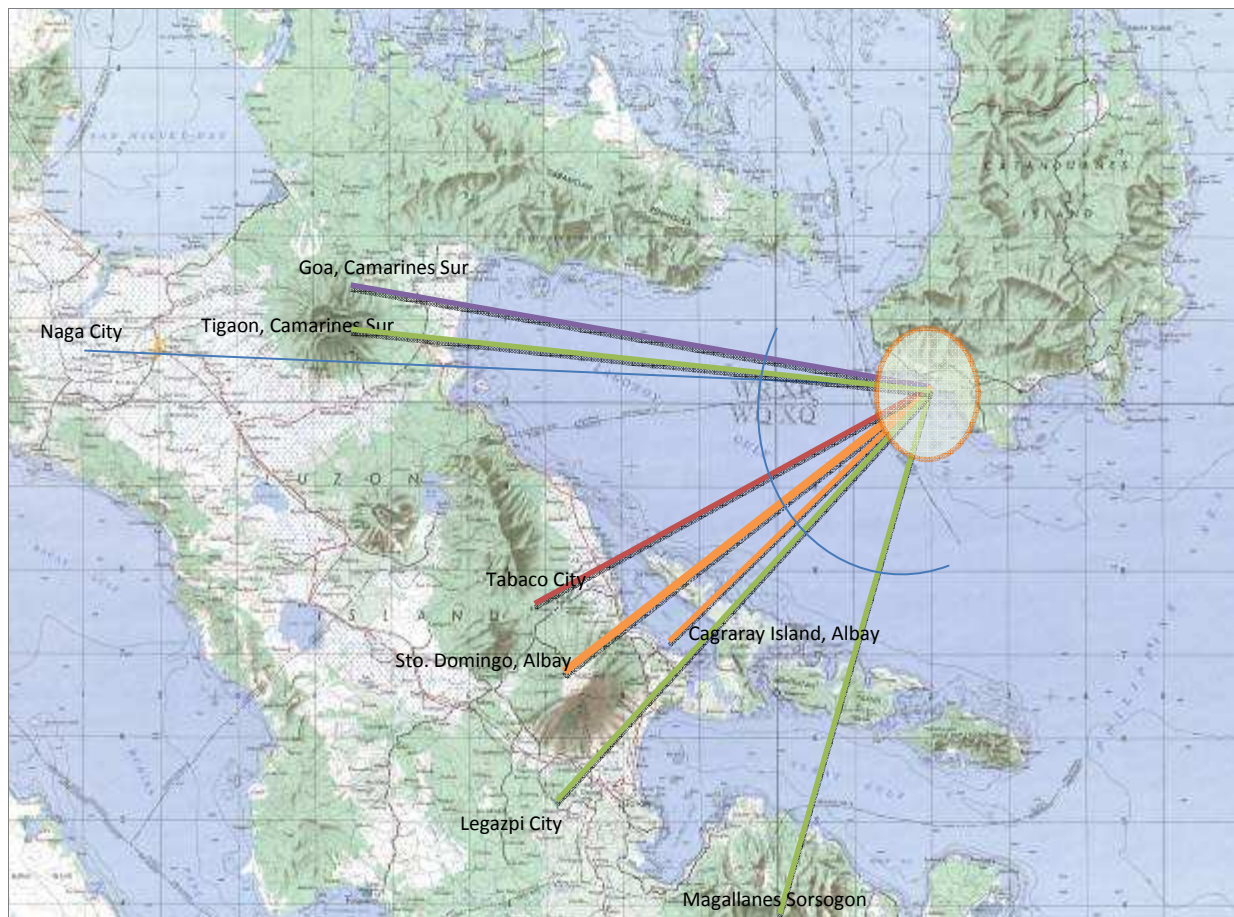


Figure8. Ranges of transmission of the antenna

CONCLUSION

Results of tests have shown that the tri-loop antenna is wideband in operation covering frequency in VHF bands. It is reliable and effective for transmitting radio signal when properly design and constructed. The antenna is cheap to construct and uses materials that are locally available and even use materials from scrap aluminum from junkshops. It serves as a good substitute to commercially available antenna for both amateur and commercial use. The antenna performs as an omnidirectional antenna.

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